Building a Global Database of Surface Seawater Dimethylsulfide (DMS) Concentrations

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Summary - Oceanic dimethylsulfide (DMS) is the dominant natural source of sulfur to the atmosphere (Bates et al., 1992; Gondwe et al., 2003). In the atmosphere DMS is oxidized to sulfuric and methanesulfonic acids which condense to form new aerosol particles and/or add mass to existing particles. These particles can affect the Earth's radiation budget by scattering solar radiation back to space and altering the properties and lifetimes of clouds (Shaw 1983, 1987; Charlson et al., 1987, 1991; Albrecht, 1989; Lohmann and Feichter, 1997; Andreae and Crutzen, 1997). Chemical transport and climate models used to estimate the effects of atmospheric particles and gases on the Earth's radiation budget must include the ocean to atmosphere flux of DMS to accurately calculate aerosol radiative forcing. The ocean to atmosphere flux is calculated from model-derived wind speeds and a database of surface seawater DMS concentrations. The goal of this project is to provide a regularly updated, web-based, interactive database of surface seawater DMS concentrations for use by the chemical/climate modeling community. The data base is being compiled from DMS measurements in the published literature and is being regularly updated with new measurements from the PMEL underway DMS system and measurements obtained from other research groups.

Why do we need a DMS database? Can't the flux of DMS from the ocean to the atmosphere be calculated from some other more easily measured or remotely sensed parameter? Do we need more surface seawater measurements?

The air-sea exchange of DMS which is a function of the gas transfer velocity and surface seawater DMS concentration. The gas transfer velocity is controlled primarily by surface turbulence, seawater temperature and gas diffusivity and can be modelled as a function of wind speed for various trace gases (Liss and Merlivat, 1986; Wanninkhof, 1992). The different models produce gas transfer velocities that vary by about a factor of two (Wanninkhof, 1992).

Unfortunately the factors controlling oceanic DMS concentrations and the parameters needed to model these concentrations are not nearly as well characterized. Existing data suggest that oceanic DMS concentrations have changed over geological time scales and continue to vary both regionally and seasonally. Ice core measurements of the atmospheric DMS oxidation product, methanesulfonate (MSA), suggest that DMS emissions (and presumably oceanic DMS concentrations) may have changed by a factor of 6 between glacial and interglacial times (Legrand et al., 1991). Seasonal studies of oceanic DMS concentrations (Bates et al., 1987; Turner et al., 1988; Leck et al., 1990; Nguyen et al., 1990; Berresheim et al., 1991; Turner et al., 1996; Dacey et al., 1998) have shown that average surface seawater DMS concentrations can vary by as much as a factor of 50 between summer and winter in the mid and high latitudes. Overall, the concentration of DMS in surface seawater varies from

approximately 0.2 nM in winter to 10 nM in summer. However, DMS concentrations in excess of 90 nM have been measured in summer plankton blooms in the North Atlantic (Malin et al., 1993) and Southern Ocean (Gibson et al., 1990; Fogelqvist, 1991). On large regional and temporal scales, DMS concentrations have been correlated with seawater chlorophyll concentrations (Thompson et al., 1990), but in general, oceanic DMS distributions are poorly correlated with phytoplankton production or biomass (Andreae, 1986, 1990; Leck et al., 1990; Kettle et al., 1999). Part of the difficultly in establishing these correlations is that the production of the DMS precursor, dimethlysulfoniopropionate (DMSP), is highly species specific (Barnard et al., 1984; Holligan et al., 1987; Iverson et al., 1989; Keller et al., 1989; Keller, 1991). In addition, actively growing cells release only small quantities of DMSP and DMS. Much higher concentrations of DMS are produced during cell senescence (Nguyen et al., 1988; Turner et al., 1988), zooplankton grazing (Dacey and Wakeham, 1986; Wolfe and Steinke, 1996), and bacterial and viral activity (Kiene and Bates, 1990; Bates et al., 1994; Ledyard and Dacey, 1994: Malin et al., 1998; Hill et al., 1998).

Another complicating factor is that most DMSP is not converted to DMS (Kiene, 1996) and furthermore, air-sea exchange is only a small sink for oceanic DMS. Instead there exists an active biological sulfur cycle within the ocean surface waters (Wakeham et al., 1987; Andreae, 1990; Belviso et al., 1990; Kiene and Bates, 1990; Leck et al., 1990; Kiene, 1992; Bates et al., 1994). From these data it is apparent that reliable parameterizations of surface oceanic DMS concentrations will require a much better understanding of the processes involved in the cycling of sulfur in the upper water column including both food web dynamics and the physical/chemical dynamics of the upper ocean (e.g. temperature, mixing, solar radiation, colored dissolved organic matter, nutrients).

What data base is currently used by the modeling community?

The current database used by the climate modeling community was assembled in 1997 by Dr. Jamie Kettle. The database was published in 1999 in the peer reviewed literature (Kettle et al., 1999) with 31 contributing authors. The database consists of 15,617 point measurements of DMS and was processed to create a series of climatological annual and monthly 1^{o} x 1^{o} latitude–longitude squares of data. Since the mid 1990's thousands of additional measurements have been made throughout the world that can be used to improve this original database. We welcome additions to this data base. If you have available data to contribute please contact Jim Johnson at James.E.Johnson@noaa.gov.

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